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ACCEPTED MANUSCRIPT

Abstract

This study examined the preferences for professional development (PD) in primary (elementary) science among pre-service teachers (PSTs) and in-service teachers (ISTs). The contribution of the study is its focus on quantifying the relative importance of factors that were significant for teachers by using Best-Worst Scaling methodology. Rather than considering potential factors in isolation, teachers traded-off among content areas of PD, thereby revealing which aspects they most preferred. A comparison of PSTs and ISTs indicated that both sought greater guidance on adapting their science teaching for multi-age classes and on strategies to engage students in activity-based science. Relative to the PSTs, the ISTs reported less need for PD opportunities that emphasised collaboration and networks, science pedagogy and content. Both groups indicated that they would most benefit from PD that focused on building their knowledge and strategies for teaching guided inquiry and investigation- and activity-based science. The findings offer critical insights into the broader improvement of PD of teachers in the context of science education.

Keywords: Teacher training; School teachers; Child; Students; Staff development; In-service training; Curriculum; Primary school, Elementary school

Introduction

Promoting students' interest in science as a chosen profession is essential for many countries to improve productivity in numerous fields and maintain international competitiveness (Marginson et al., 2013). In the United States, the demand for professional science and engineering jobs is expected to increase by 13% by 2026, compared to an expected 7% growth in the overall workforce (National Science Board, 2020). In Australia, the professional, scientific, and technical services area is expected to experience high growth, with a 10.2% increase in jobs by 2025 (Australian Government, 2020).

In primary (elementary) and even pre-school years, teachers can influence children's motivation for science (Archer et al., 2013; Lyons & Quinn, 2010; Oppermann et al., 2019; Osborne et al., 2003; Rivkin et al. 2005). However, teachers themselves can lack the self-efficacy, content knowledge, and skills to teach science competently (Aubusson et al., 2015a, 2015b; Tytler et al., 2008). Hence, alongside adequate teacher training, mentoring, and networking, an important objective of science education is to provide professional development (PD) programs for teachers to encourage students' motivation and achievement in the subject (de Vries et al., 2013). Successful PD enhances the knowledge, skills, beliefs, and practices of teachers (Knapp, 2003; Timperley, 2011). In their review of PD effectiveness, Guskey and Yoon (2009) reported that the most frequently cited factor for improving PD was enhancement of teachers' content and pedagogical knowledge. Similarly, Darling-Hammond et al. (2017) concluded that PD is most effective when it is content focused and concentrates on teaching strategies associated with specific curricula that support teacher learning within classroom contexts unique to each teacher.

The present research aims to address the following research question: "What are primary pre- and in-service teachers' relative preferences among factors in the effective design of PD in science?" We examine variations in form (e.g., study group; internship), facilitation (e.g., multiple instructors; teachers as facilitators), duration, length, and location of programs (e.g., multiple sites; at school), and types of student (e.g., grade levels; different schools) (Birman et al., 2000; Borko, 2004). A further contribution is the use of best-worst scaling (BWS), a method first proposed by Finn and Louviere (1992) to quantify the relative importance of public concerns, such as food safety or crime. We adapt this method to quantify which content areas are perceived by primary science teachers as most important in the effective design of PD. We also consider the differences in perceptions of effective PD between two sets of teachers, namely pre-service teachers (PSTs) and in-service teachers (ISTs), which further contributes to previous literature that highlights how the two teacher groups differ with respect to pedagogical knowledge, beliefs, and practices (Meschede et al., 2017).

The research objective and accompanying methodology focuses on the question of relative importance with the aim of discriminating among various factors that have been offered in the literature as providing some value to the effective design of PD. To date, whilst many factors have been nominated as important in this regard, there is no empirical evidence to account for which factor is more valued by teachers as a focal part of PD activities relative to another. The value of providing such insights is to guide the effective design of PD for those charged with their set up and thereby to increase the value of PD programs for participating teachers; ultimately such improvements will improve learning outcomes for students (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2009). Standard methodological approaches to questions of importance, such as those involving the separate rating of factors on important (e.g., via Likert scales), potentially inform stakeholders that all factors are important (Louviere & Islam, 2008; Massey, Wang, Waller, & Lanasier, 2015; Van Vaerenbergh & Thomas, 2013). This offers little strategic direction for improving PD including how to best improve curriculum design of PD programs or where to focus support resources for participants. A further aim of this research is to understand whether the factors that are most valued by in-service teachers significantly differ to pre-service teachers. In turn, this further offers potentially a different set of outcomes for how PD can be contextualised to better serve these two sets of teacher segments (Oppermann, Brunner, & Anders, 2019).

The remainder of this paper is organised into six sections. First, we review previous research examining effective PD in the teaching of primary science. Second, we describe how a list of factors related to PD preferences was generated and considered by PSTs and ISTs in the BWS task. Third, we outline our online BWS survey used to quantify the relative importance of these factors. Fourth, we present our research findings. Fifth, we discuss the implications of these. Finally, we consider the limitations of the study and future research opportunities.

Literature Review

In their study of PD involving over a thousand teachers, Birman et al. (2000) concluded that PD is most valuable when it offers high-quality experiences that develop content knowledge, are coherent with classroom practice, and where teachers play an active role in student learning. Programs that positively impact teacher knowledge, skills, beliefs, and ultimately student learning, should focus on content knowledge; active learning; coherence in the sequence of learning; opportunities for collaboration; duration and sustainability; and adequate support (Borko et al., 2010; Desimone, 2009; Loucks-Horsley et al., 2009; Luft & Hewson, 2014). Aubusson et al. (2015a) surveyed 173 primary school teachers in Australia and found that they preferred PD programs that included experts' input, sustained in-school support, and teacher collaboration, and that there is a need for high quality science-focused PD programs for primary teachers, who are generalists and typically have limited preparation for teaching science.

Primary teachers' lack of confidence to teach science and limited knowledge of science content and inquiry pedagogy is well documented (Alake-Tuenter et al., 2012; Capps & Crawford, 2013; Fitzgerald et al., 2019; Johnson, 2006; Murphy et al. 2007; Rennie et al., 2001; van Aalderen-Smeets et al., 2012). Roth (2014) argued that high-leverage PD initiatives have "meaningful conceptual frameworks for teachers", such as "teaching science as argument" and "modelling-centred inquiry" (p. 383). PD that is sustained, content based and coherent has been shown to improve teachers' competence and confidence (Maeng et al., 2020).

After undertaking PD programs, teachers have attributed changes in classroom practices to:

- content, active participation, collaboration, and duration of the program (Murphy et al., 2015);
- meaningful context, varied strategies, and school-based programs catering for student interests (Paige et al. 2016); and,
- using inquiry as their students would, rich practical resources, demonstrations and strategies that connect to curriculum standards, and the maintenance of support (Maeng et al., 2020; Nichols et al., 2016).

The literature also points to barriers to the successful implementation of PD. These include limited resources, time constraints, mandated curriculum pacing, classroom management issues (Buczynski & Hansen, 2010), and failure to reveal and address teacher's beliefs (Lowe & Appleton, 2015). Valuable professional development activities encourage teachers to move beyond the 'what' of their teaching and a focus on its operational elements, to consider the 'why' of their current and new ways of working, reflecting on how each can impact student learning (Smith, 2017).

In summary, the factors influencing the effectiveness of primary science teachers' PD highlighted in previous literature include: teachers' confidence to teach science; content knowledge and associated pedagogical content knowledge; beliefs about science teaching and learning; knowledge of inquiry pedagogies; ability to remove or minimise barriers relating to resources and time constraints, as well as ability to improve their management of curriculum and the classroom environment. In order to develop effective PD, it is therefore crucial to understand those factors that are most important for teachers, and if these differ among PSTs and ISTs.

Method

Overview and Study Context

In this study we used the professional development program *Primary Connections* (PC) as the context to address the research question, "What are primary pre- and in-service teachers' preferences in the design of PD in science?" An initiative of the Australian Academy of Science (AAS), the PC program was developed to enhance primary school teachers' confidence and competence for teaching science (AAS, 2021; Hackling et al., 2007)

Supported by curriculum resources, it models inquiry-based teaching and learning, which is an approach to teaching science now mandated in Australia (Australian Curriculum and Assessment Reporting Authority [ACARA], 2014). In PC workshops throughout Australia, trained PD facilitators provide primary teachers opportunities to practice science teaching by supporting them with resources and reflections on practice linked to a set of learning and teaching principles. The basis of the PC program is the 5Es model (Bybee, 2014) of learning progression (namely, Engage, Explore, Explain, Elaborate, and Evaluate). The program is a successful national initiative with face-to-face workshops and online resources that encourage teachers to embrace constructivist and inquiry-oriented pedagogies, particularly in rural and remote locations of Australia (Aubusson et al., 2019). PD has been shown to address the challenges of attracting and retaining teachers at such difficult-to-staff locations (Buchanan et al., 2013; Burke et al., 2015).

The study used Best-Worst Scaling (BWS) (Finn & Louviere, 1992) to determine which factors in the PC program PSTs and ISTs considered most beneficial when choosing PD. The BWS task discriminated between these factors, allowing their relative importance to be quantified and compared. The manner in which factors were identified for inclusion in the BWS are described in the next section.

Developing the List of Factors

To address the research objectives, a comprehensive list of factors was developed. An initial list of content-related factors considered important to include in the PC program was based on existing literature, including reference to a systematic literature review of 68 papers published between 2006 and 2017 to determine evidence-based characteristics of effective PD in primary science (Aubusson et al., 2019). The list was further supplemented with data from several rounds of consultation with PSTs and ISTs, consultants, administrators, and academics. These discussions included six focus groups (three with PSTs, and three with ISTs), which were held immediately following a PC workshop. The list was further refined by four science education experts on the research team in a three-stage process. First, items were added to the list that were consistent with the stated goals and aims of the PC workshops, but were not evident in the focus group data. Second, the list was reduced through categorising similar factors and with a concern for clarity and comprehension of statements for participants. Finally, a discussion with members of the AAS involved in the delivery of the program further developed the list with respect to terminology and comprehension. The final list of 25 factors is presented in Table 1.

Table 1 about here

Overview of the BWS Instrument

The overarching objective of the current research was to understand the areas that the PSTs and ISTs would prefer as inclusions in PC workshops. In a typical survey, participants would be asked about each factor and to rate their replies on a scale, such as from “not at all important” to “very important”. In other words, they would consider each of the 25 factors singly, rather than evaluate the relative importance of each factor as compared to others. Nominating all factors as “very important” would not reveal which factors were perceived as more or less important (Carson et al., 2004). Another common technique would be to ask participants to rank the factors, but ranking all 25 factors at one time would place considerable cognitive load on participants. In contrast to such approaches, the BWS instrument forces participants to nominate which factor is relatively more important as compared to other factors presented in statistically controlled subsets.

BWS was developed by Louviere and Woodworth (1990) and first published by Finn and Louviere (1992), with Marley and Louviere (2005) providing formal mathematical proofs. The BWS ranking is achieved by asking respondents to choose their best and worst option from subsets of factors determined by an appropriate experimental design. These sets present the factors multiple times, in different combinations. Respondents do not need to state their preference for each factor within the set, but rather perform the less cognitively challenging task of choosing the factors deemed most important (best) and least important (worst) within the set presented. By comparing the choices they make within each set, a hierarchy of the mean relative importance of all factors can be created and quantified.

The BWS approach allowed a score to be determined for each of the 25 PD topic statements. The score can be interpreted as an index describing whether a teacher will nominate a PD topic as more important relative to another factor, averaged across its co-occurrence with all other factors. To aid interpretation, each score has been standardised with respect to the least and most important topic, scored zero and 100 respectively.

In the BWS task, the respondents began by evaluating a subset of five of the 25 factors presented in an online survey. Figure 1 shows one of the subsets. Each teacher nominated the factor that was most important and, once they had selected that option, it disappeared from the list, leaving them four remaining factors to rank. In this way, they continued to nominate factors that mattered more until all five statements in this subset were fully ranked from most to least important. A "none of these are factors" option was trialled but found to disrupt the cognitive flow of the task; instead, it was taken account of using a Likert-scale question. A statistical design revealed which factors, on average, presented themselves as more relevant to respondents as a PD topic for inclusion in PC.

Figure 1 about here

BWS is attractive because it forces respondents to discriminate among objects (in this case, topics for inclusion in PD) in terms of their relative importance (Louviere & Islam, 2008). Another key characteristic is that the response provided to respondents is a discrete outcome (choice) rather than a rating on a continuous scale (e.g., 1 to 7). This avoids several response-style biases that have been found in prior research using such scales (Van Vaerenbergh & Thomas, 2013). For example, some respondents might tend to avoid the extreme ends of the rating scale, while others might remain neutral. BWS is also cognitively easy for respondents; there is no allocating of points or percentages to items or the need to rank a lengthy list of items simultaneously (Louviere & Islam, 2008). In this study, BWS made the task easier for the teachers to complete and reduced overall response times without compromising measurement reliability (Driesener & Romaniuk, 2006). It is also worth noting that in contrast to rating-scale approaches, BWS purposely minimises rather than maximises inter-item correlations. Thus, it maximised discrimination in the measuring of the topics important to participating teachers across the factors (Burke et al., 2018).

Burke et al. (2013) first introduced BWS to education to quantify which factors impacted early career teachers more in their decisions about staying in the profession. The method has since been used to classify teachers' stages of concern in relation to an educational technology to predict its levels of adoption in the classroom (Burke et al., 2018), and to measure the relative importance of pedagogical principles in cases where students use mobile devices for learning (Burden et al., 2019). Relevant to the current study is a set of applications of BWS examining school students' reasons for rejecting or undertaking a subject (Palmer, 2015; Palmer et al., 2017).

Results

Sample

The BWS was completed online following an email invitation sent by AAS to PSTs and ISTs who had completed one of their previous PC workshops in the past year. The AAS database contained the email listing of approximately 1000 teachers from more than 500 schools who attended 30 PC teacher training workshops in the last year. To address issues of database inaccuracies (e.g., incorrect emails), the survey link was posted on the AAS Facebook page and participants were encouraged to forward the survey to their teaching colleagues. All respondents were screened on the basis of having completed a PC workshop and had taught within the last five years. Of the 184 pre-service teachers who commenced the survey, 20 respondents did not qualify (e.g. did not agree to participate; had not taught within the last five years), with 126 of the 166 qualified in-service teachers (76.8%) completing the survey in full. In the case of pre-service teachers, 224 respondents commenced the survey, with only one respondent did not agree to participate. Of the qualified 223 PST respondents, 171 (77%) completed the survey in full.

The median survey completion time was 14.8 minutes. All 171 PSTs and 126 ISTs participating had taught during the prior five years. With the exception of Kindergarten[1], there was a uniform representation of experiences in teaching across the primary year levels (aged 5 to 12 years), although 16% had taught Years 7 (aged 12 to 13 years) to 10 (aged 15 to 16 years), and 6% had taught Years 11 (aged 16 to 17 years) and 12 (aged 17 to 18 years)[2]. The ISTs came from all Australian states and territories, the majority (94%) from small cities or towns, and the PSTs were more likely to be from larger cities or towns, including those located in the country (23%), coast (23%), or the capital (40%).

BWS Scores

The BWS scores were calculated for each factor by standardizing the difference between the frequency with which a factor was nominated as most important (i.e., best) and the frequency with which a factor was nominated as least important (i.e., worst) with respect to the frequency with which the factor appeared across the choice sets (Marley, Flynn, & Louviere, 2008; Massey et al. 2015). To aid interpretation, the scores were rescaled resulting in scores ranging from 0 and 100 representing the factor with the highest and lowest BWS importance scores among ISTs, respectively.

[1] Kindergarten is the first year of formal schooling. In some Australian states and territories, it is referred to as Preparatory, Pre-Primary, or Reception. Students are aged 5 to 6 years.
[2] Years 7 to 12 are secondary school years in Australia.

The scores sorted for ISTs are presented Figure 2, and those for PSTs are in Figure 3.

Figures 2 and 3 about here

Table 2 presents the top 10 PD topics ranked by both PSTs and ISTs as most important for inclusion in PC.

Table 2 about here

A comparison of the two sets of results for PSTs and ISTs shows general agreement on the topics of importance (r = .867), with some exceptions. Table 3 presents the normalised BWS scores of both the PSTs and ISTs for comparison, sorted by descending importance among IST teachers. To evaluate the differences in mean scores across the two teacher groups, PSTs and ISTs, an independent samples t-test was performed, with the significance of these differences noted in the final column of Table 3 and discussed below.

Table 3 about here

Both PSTs and ISTs agreed that the inclusion of “investigation-based science” was preferred relative to other topics in a PD program for science (p = .055). “Science teaching strategies” was among the top two items for both groups, with PSTs more likely to nominate it as most important for inclusion ($p < .01$). Similarly, both groups nominated “guided inquiry in science”, with the difference in the average BWS attached to this topic not significantly different across the PSTs and ISTs (p = .278).

At the other extreme, both PSTs and ISTs agreed the following three areas were the least important for inclusion in the PC program:

- developing PC professional learning networks (p = .742);
- management and organisation of science equipment and materials (p = .547); and,
- argument-based science (p = .574).

While the ISTs nominated "collaboration with fellow teachers or pre-service teachers" as the least important area for inclusion, PSTs ranked this item significantly higher (p < .001), although both groups agreed it was among the bottom five factors based on importance overall. "Evidence-based science" was ranked quite low by ISTs and appeared in the bottom five factors, but marginally higher as the 17th most important factor for PSTs; however, the differences in mean BWS scores were not significant different (p = .291).

ISTs placed significantly greater importance on including the following factors in PD: "condensing PC units for the available time" (p <.001); "adapting it for multi-stage delivery" (p <.001); and "integrating digital technologies in science" (p <.001). By contrast, PSTs nominated the following factors for inclusion in PD: "collaborating with fellow teachers or PSTs" (p <.0001); "science pedagogy" (p <.001); "students' collaborative learning in science" (p <.01); "science content knowledge" (p <.01); and "implementing the 5Es" (p <.01). Other significant differences in mean BWS scores across the two groups are shown in Table 3.

Discussion

The results of this study provide insight into PSTs' and ISTs' preferences for components of PD in primary science. The overarching objective was to understand which factors are more significant in terms of their importance to PSTs and ISTs in relative terms. For instance, would teachers prefer to learn about adapting the PC program for multi-age classes, or about managing and organising science equipment and materials?

The list of evidence-based characteristics for the BWS task covered teaching strategies, science pedagogy theory, programming, collaboration needs, and classroom logistics. The BWS methodology revealed that PSTs and ISTs mostly agreed on the important factors to include in PD. For example, both groups preferred to participate in instructional strategies. Of the topics they chose as most important, "activity-based science", "doing hands-on science activities", and "investigation-based science" all ranked highly. This supports previous research that suggests the term "inquiry" is often confused with hands-on instruction (Fitzgerald et al., 2019; Johnson, 2006). The BWS factors chosen were related to building competence in teaching science through practical hands-on and inquiry-based teaching strategies they could use in the classroom, suggesting both are important.

In reviewing the top 10 factors for inclusion in PD, PSTs and ISTs disagreed on the importance of two topics: "understanding the PC approach" and "adapting PC for multi-age classes". In both cases, ISTs ranked these factors higher than PSTs. As the PC program is well known in Australian schools, this may indicate that ISTs seek PD that elaborates on a teaching resource they are already aware of and somewhat familiar with.

There were other differences between PSTs' and ISTs' preferences. ISTs placed more importance on customising the PC materials ("condensing PC units for the available time" and "adapting it for multi-age class delivery") than PSTs. This is not surprising given that ISTs are more experienced and would appreciate the need to modify teaching materials to make the most of the time available for lessons. They were also more interested in PD that addressed adapting PC for multi-age classes and in the PC approach more broadly. Finally, ISTs were more interested in the topic of STEM in primary schools than PSTs.

PSTs placed more importance on "collaboration with fellow teachers" and "student collaborative learning in science" than ISTs. However, both groups ranked "collaboration with fellow teachers" as relatively unimportant. Similarly, both PSTs and ISTs agreed that "developing professional development networks" was of low relative importance. This may be because they already had strong professional networks, or they felt they did not need them to improve their teaching of science. The research sample was drawn from the database of the AAS and hence these teachers were already connected through that network. The participants also agreed the topic "management and organisation of science equipment and materials" was relatively unimportant, perhaps because ISTs had already addressed this issue and PSTs had not yet considered it. "Argument-based science" was the least important topic for both groups. This was a surprising finding, given the literature suggests this topic can be problematic for teachers (Simon et al., 2006).

This study makes a unique contribution to the field as the BWS methodology allowed teachers' preferences for potential PD factors to be ranked and quantified. The findings can inform decisions on how to address the concerns of teachers in future PD offerings, rather than expending effort to address factors such as science content and concepts, found to be of relatively less concern. Our results suggest that both PSTs and ISTs value PD that supports their development of skills in how to teach hands-on and inquiry-based science.

Limitations and Future Research

While primary teachers are keen to develop their students' interest in science (Lyons & Quinn, 2020; Wang et al., 2017), students' perceptions of their teachers' encouragement have also been cited as affecting their individual differences in motivation (Fouad et al., 2010). Improving PD activities may address this need. The current research offers insights into fostering relevant PD content for PSTs and ISTs participating in such programs.

The teachers undertaking the BWS survey had previously completed the introductory PC program. An extended BWS study could examine whether participants who had not done so might rate the same topics differently. Similarly, the sample had a high representation of in-service teachers from rural and remote schools. With PD nominated as valuable for preventing attrition in such regions (Burke et al., 2015), it would be interesting to examine whether preferences for PD content in science might differ among teachers working in metropolitan regions. And, since the context of the study was a well-known PD program in Australia, it would be worthwhile to address the generalisability of its findings by adapting the research to other settings internationally. Future research is also needed to explore whether PSTs and ISTs would continue to regard "argumentation" as the least important factor and why they might require additional instruction in classroom skills in science.

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Declarations

The research received ethics approval from the University of Technology Sydney Human Research Ethics Committee (UTS HREC ETH17-1280) with all participants consenting to their participation (study overview and consent available upon request).

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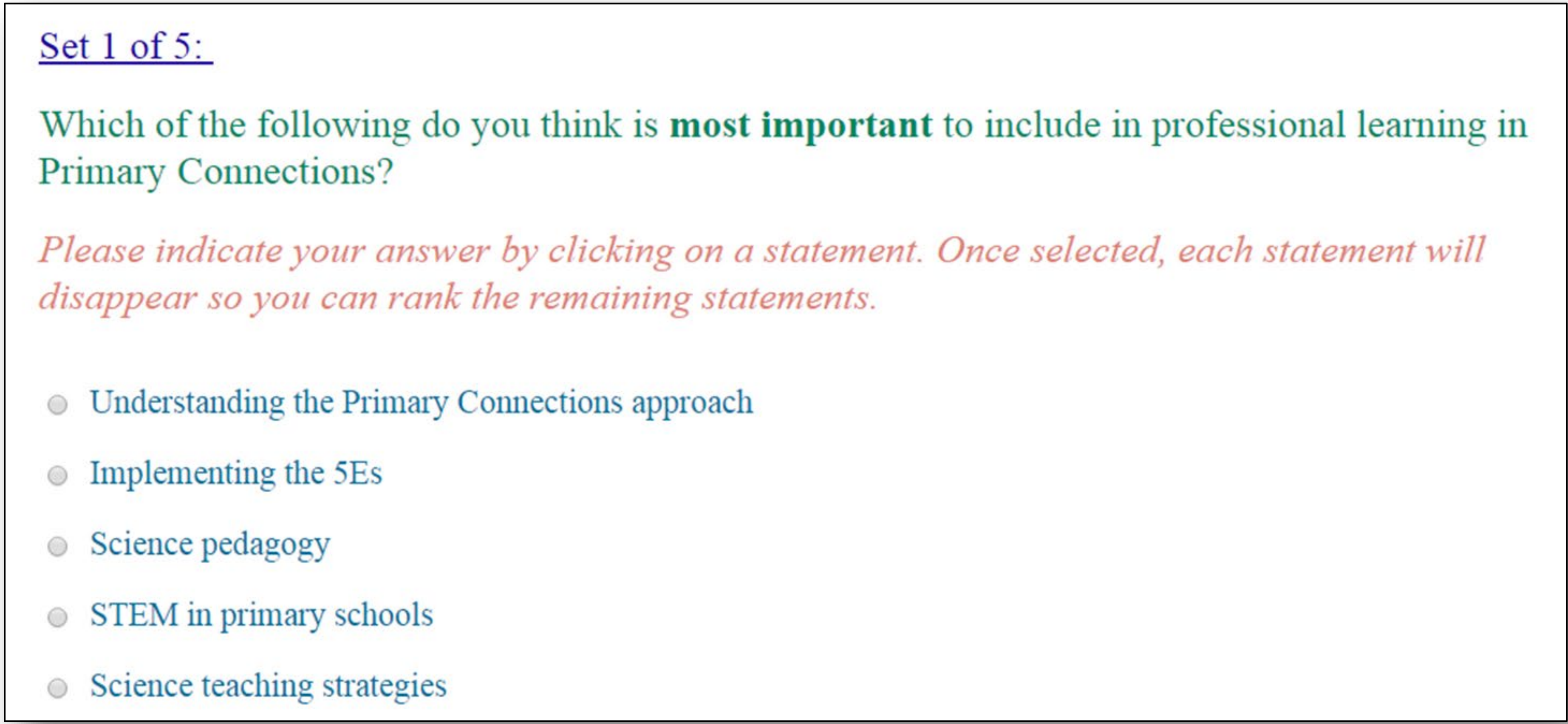

Figure 1. Example of BWS Survey Question

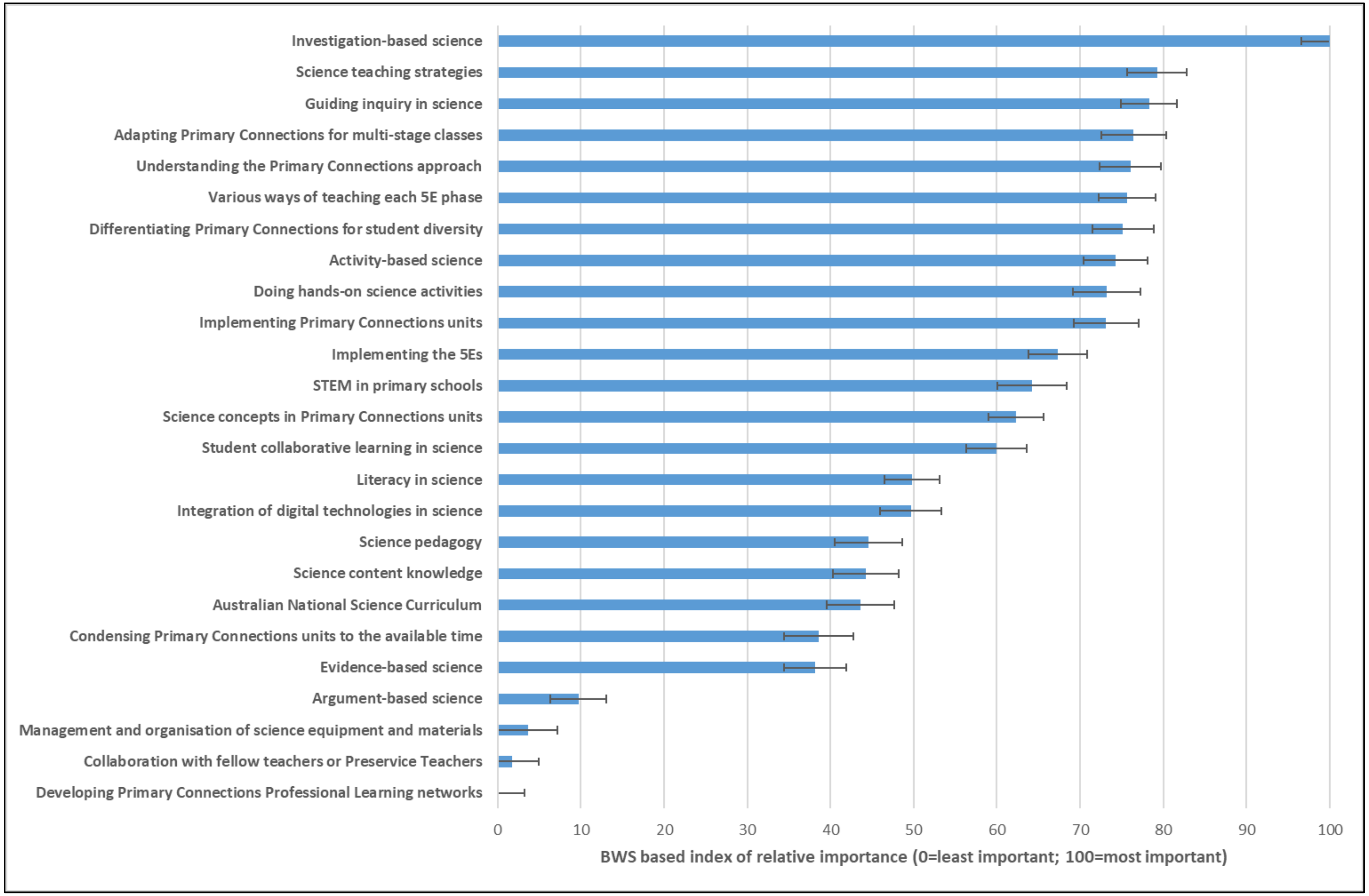

Figure 2. Ranking and scores of importance of PD topic areas (In-Service Teachers)

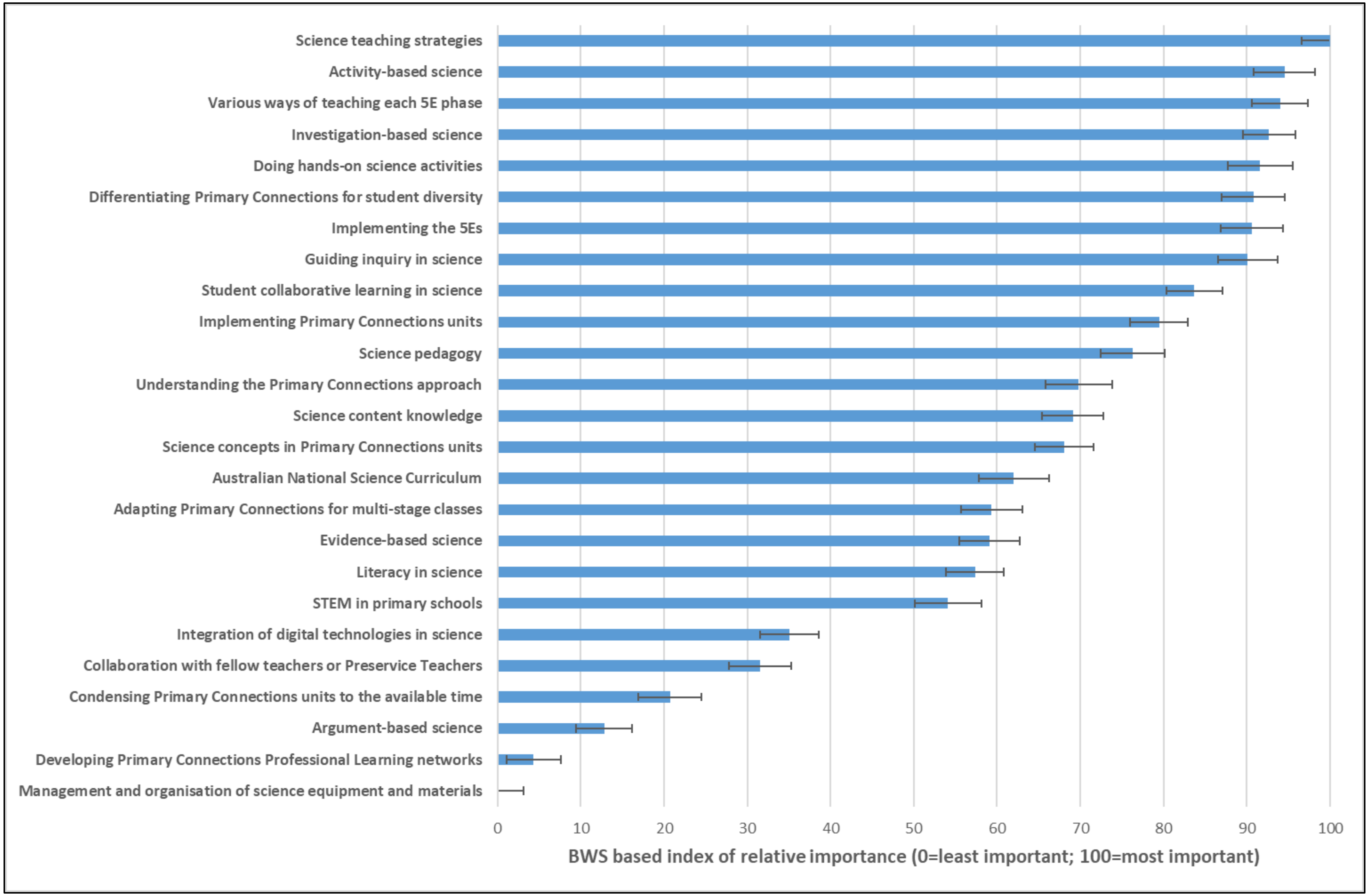

Figure 3. Ranking and scores of importance of PD topic areas (Pre-Service Teachers)

Table 1: Topics teachers were asked to consider in BWS study

Topics included in study	Topics included in study
Science Pedagogy:	***Collaboration:***
Argument-based science	Collaboration with fellow teachers or Pre-service Teachers
Evidence-based science	Developing PC professional learning networks
Literacy in science	
Science pedagogy	***Content:***
Understanding the PC approach	Australian National Science Curriculum
Investigation-based science	Science concepts in PC units
	Science content knowledge
Teaching Strategies:	Science Technology Engineering and Mathematics (STEM) in primary schools
Activity-based science	
Doing hands-on science activities	***Programming:***
Guiding inquiry in science	Adapting PC for multi-stage classes
Implementing PC units	Condensing PC units to the available time
Implementing the 5Es	Differentiating PC for student diversity
Integration of digital technologies in science	Management and organisation of science equipment and materials
Science teaching strategies	
Student collaborative learning in science	
Various ways of teaching each 5E phase	

Table 2: Top ten ranked topics for inclusion in PD in PC

	Pre-service teachers		**In-service teachers**	
Rank	**Topic**	**Focus of topic**	**Topic**	**Focus of topic**
1	Science teaching strategies	Teaching strategies	Investigation-based science	Science Pedagogy
2	Activity-based science	Teaching strategies	Science teaching strategies	Teaching strategies
3	Various ways of teaching each 5E phase	Teaching strategies	Guiding inquiry in science	Teaching strategies
4	Doing hands-on science activities	Teaching strategies	Adapting PC for multi-stage classes	Programming
5	Investigation-based science	Teaching strategies	Understanding the PC approach	Science Pedagogy
6	Differentiating PC for student diversity	Programming	Various ways of teaching each 5E phase	Teaching strategies
7	Implementing the 5Es	Teaching strategies	Differentiating PC for student diversity	Programming
8	Guiding inquiry in science	Teaching strategies	Activity-based science	Teaching strategies
9	Student collaborative learning in science	Teaching strategies	Doing hands-on science activities	Teaching strategies
10	Implementing PC units	Teaching strategies	Implementing PC units	Teaching strategies

Table 3: Difference in BWS scores for in-service and pre-service teachers

	In-service teachers		Pre-service teachers		Difference in mean BWS scores		
Item for inclusion in PD	**Mean**	**S.E.**	**Mean**	**S.E.**	**Mean**	**p-value**	**sig.**
Investigation-based science	100.00	1.72	88.55	1.61	11.20	0.055	
Science teaching strategies	79.27	1.82	100.00	1.75	-20.76	0.001	**
Guiding inquiry in science	78.27	1.71	84.80	1.84	-6.73	0.278	
Adapting PC for multi-stage classes	76.44	1.99	45.27	1.90	30.98	0.000	**
Understanding the PC approach	76.03	1.90	57.48	2.02	18.35	0.008	**
Various ways of teaching each 5E phase	75.64	1.75	90.56	1.71	-15.11	0.013	*
Differentiating PC for student diversity	75.16	1.86	85.76	1.93	-10.79	0.104	
Activity-based science	74.26	1.97	91.34	1.89	-17.27	0.011	*
Doing hands-on science activities	73.21	2.06	86.99	1.98	-13.98	0.048	*
Implementing PC units	73.10	1.99	69.87	1.78	3.05	0.644	
Implementing the 5Es	67.29	1.80	85.53	1.89	-18.41	0.004	**
STEM in primary schools	64.22	2.14	39.60	2.04	24.46	0.001	**
Science concepts in PC units	62.29	1.67	55.33	1.80	6.80	0.263	
Student collaborative learning in science	59.94	1.86	75.67	1.72	-15.88	0.011	*
Literacy in science	49.78	1.69	43.08	1.78	6.58	0.278	
Integration of digital technologies in science	49.68	1.87	21.80	1.79	27.74	0.000	**
Science pedagogy	44.57	2.08	65.65	1.97	-21.19	0.003	**
Science content knowledge	44.25	1.99	56.58	1.87	-12.44	0.066	
Australian National Science Curriculum	43.63	2.07	48.26	2.16	-4.74	0.521	
Condensing PC units to the available time	38.58	2.14	11.15	1.92	27.33	0.000	**
Evidence-based science	38.17	1.89	44.98	1.85	-6.91	0.291	
Argument-based science	9.71	1.70	6.31	1.72	3.37	0.574	
Management & organisation of science equipment & materials	3.64	1.83	0.00	1.61	3.63	0.547	
Collaboration with fellow teachers or Pre-service Teachers	1.73	1.63	18.96	1.92	-17.25	0.006	**
Developing PC professional learning networks	0.00	1.67	1.92	1.66	-1.92	0.742	

Mean = normalised BWS score; S.E. = standard error; $^{*}p < .05$; $^{**}p < .01$.